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Greenup L&D Miter Gate Repair and Instrumentation

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Background

- Greenup L&D is on the Ohio River five miles below Greenup, KY
- Main lock 110 ft wide by 1200 ft long, Aux lock 110 ft wide by 600 ft long
- Greenup locks is the 8th busiest of the Corps' locks
  - Commercial tonnage has averaged 70 million tons over the last five years
  - Approximately 7200 lockages per year
- Locks were placed in service in 1959
- Other features
  - Nine Tainter gates,
  - 70,000 kW hydroelectric plant
  - Highway bridge

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Background

- Main and auxiliary locks have upstream and downstream miter gates and emergency lift gates
- Miter gates are horizontally framed, 15 girders
- Chamber height is 67 feet
- Normal lift is 30 feet

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Background

- In September 2003, the main lock chamber was dewatered for scheduled maintenance
- The outage was scheduled to last three weeks

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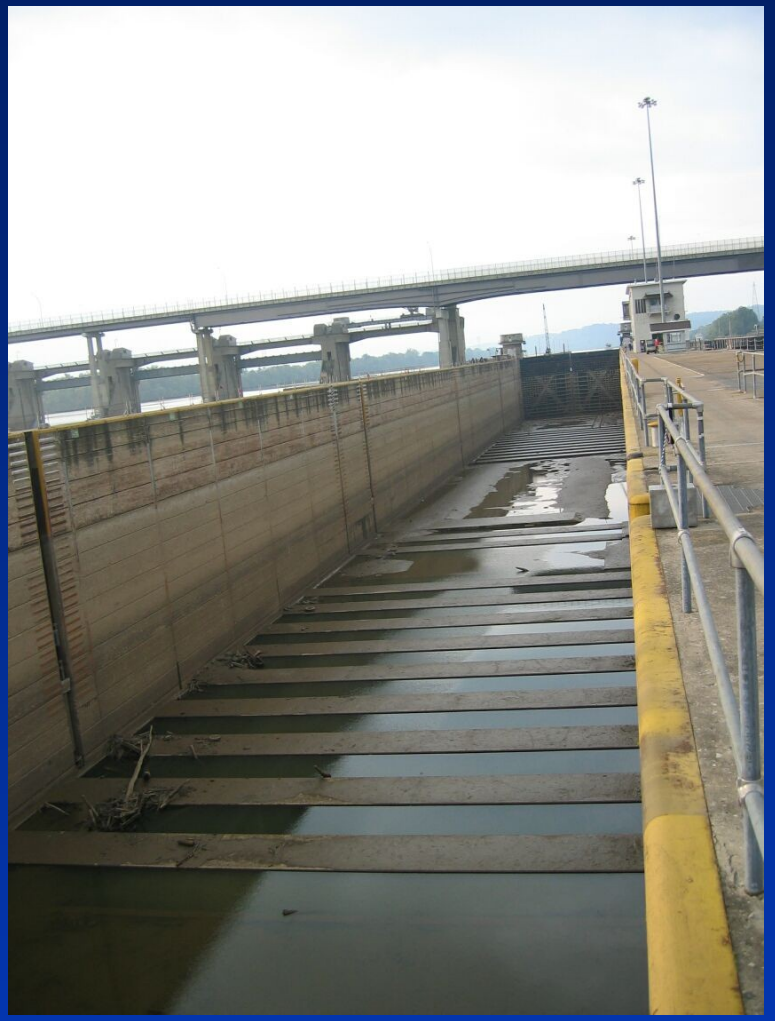

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Miter Gate Damage

- **Cracking at reinforcement gussets**
- Cracking around pintle casting
- Out-of-plane deformation of thrust diaphragm
- Out-of-plane deformation of Girder 15 web

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Miter Gate Repairs

- Remove triangular gussets and replace with radiused gussets
- Remove and replace cracked flanges
- Heat straighten out-of-plane distortion of thrust diaphragm and girder web
- Add stiffeners to thrust diaphragm and girder web
- Reset quoin block
- Work was driven by the need to return lock to service as soon as possible!

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Cause of Miter Gate Damage?

- A suspected cause of pintle cracking and out-of-plane distortion of girder web and thrust diaphragm was lack of bearing of quoin block at the bottom portion of the gate

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Miter Gate Damage Instrumentation

- An instrumentation plan was developed to monitor behavior of girders and diaphragm around the pintle
- Short term objective was to verify behavior of bottom girders
- Long term objective was to monitor girders and diaphragm for changes in behavior over time as a result of shifting or misalignment of the gate, cracking or other damage

Gate Instrumentation

Gages Installed:

20 - Full-bridge strain gage sensors on Gate

2 – Strain gages on the Strut Arms

2 - Pressure Cells (lower pool and chamber)

1 – wire potentiometer (on gate opening mechanism)

Gate Instrumentation

Strain Gage Locations

Gage Sets 1, 2, 3, and 5 were installed on horizontal flange of the G13, and G15 Girders

Gage Set 4 was installed on the vertical girder flange

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Strain Gage Locations

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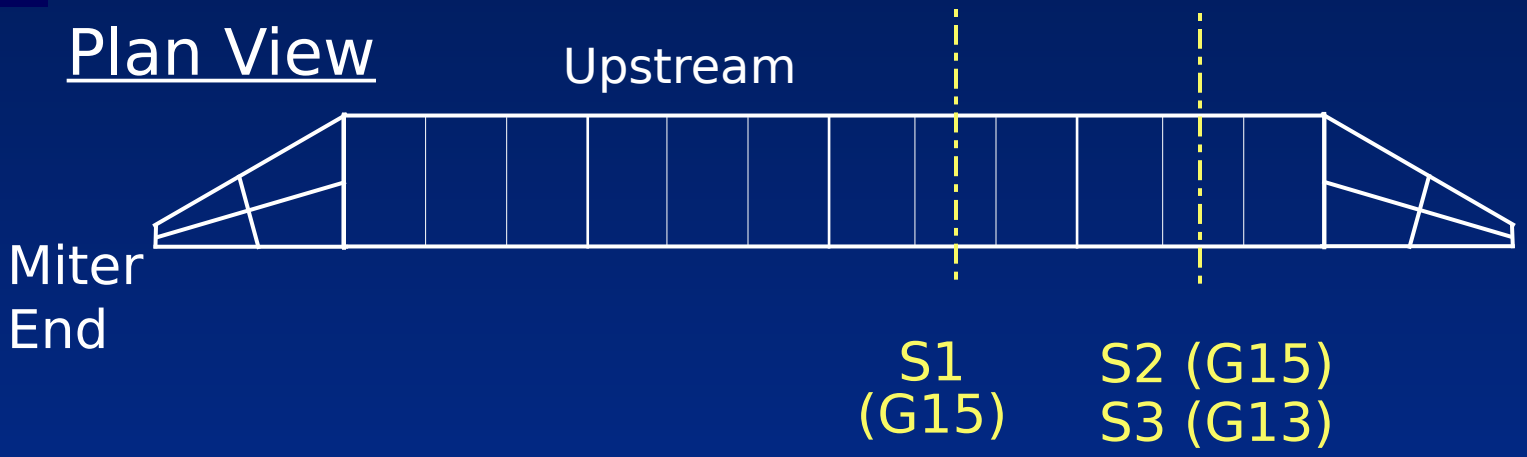
Plan View



Section

Strain Gage Locations

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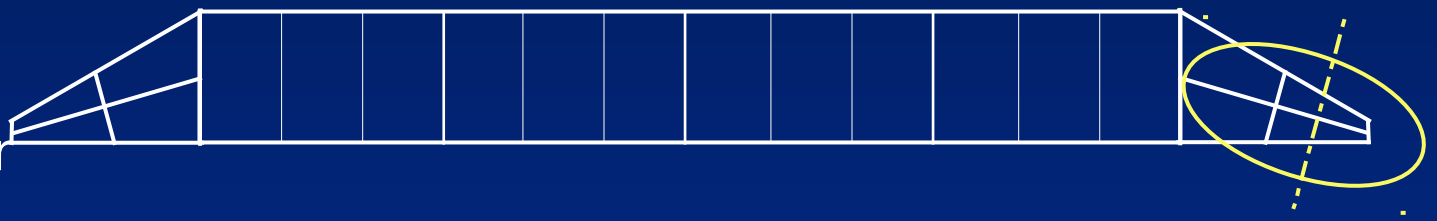
Plan View



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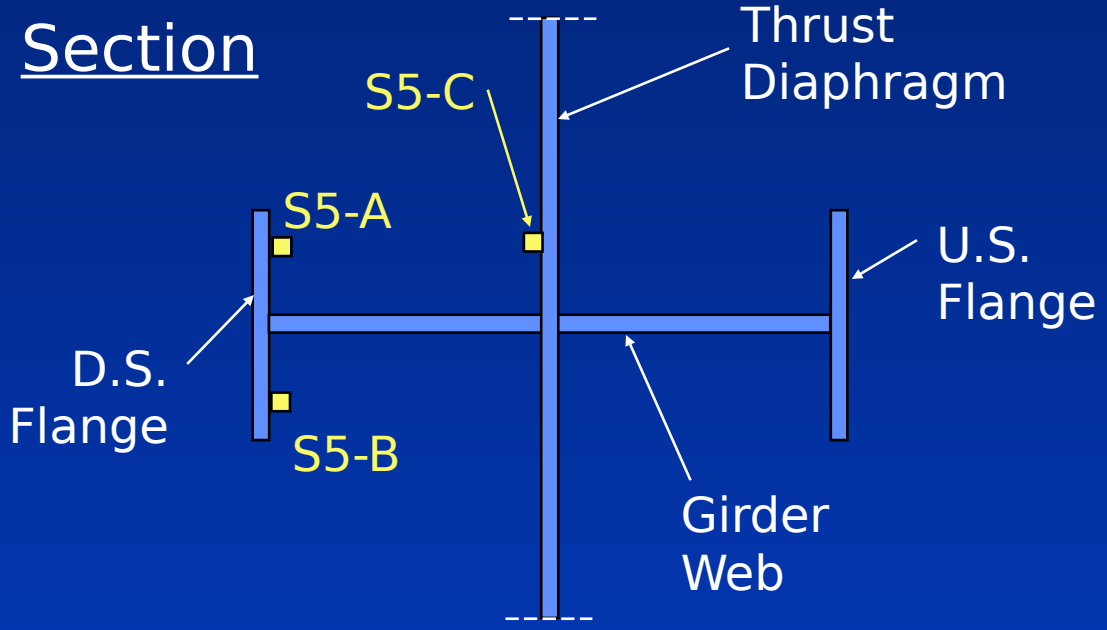

Strain Gage Locations

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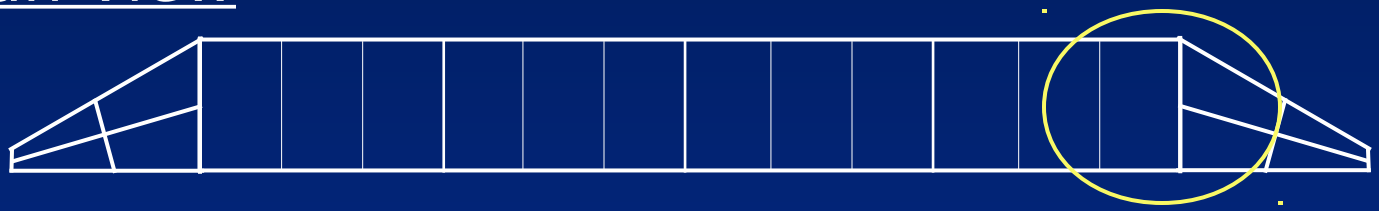
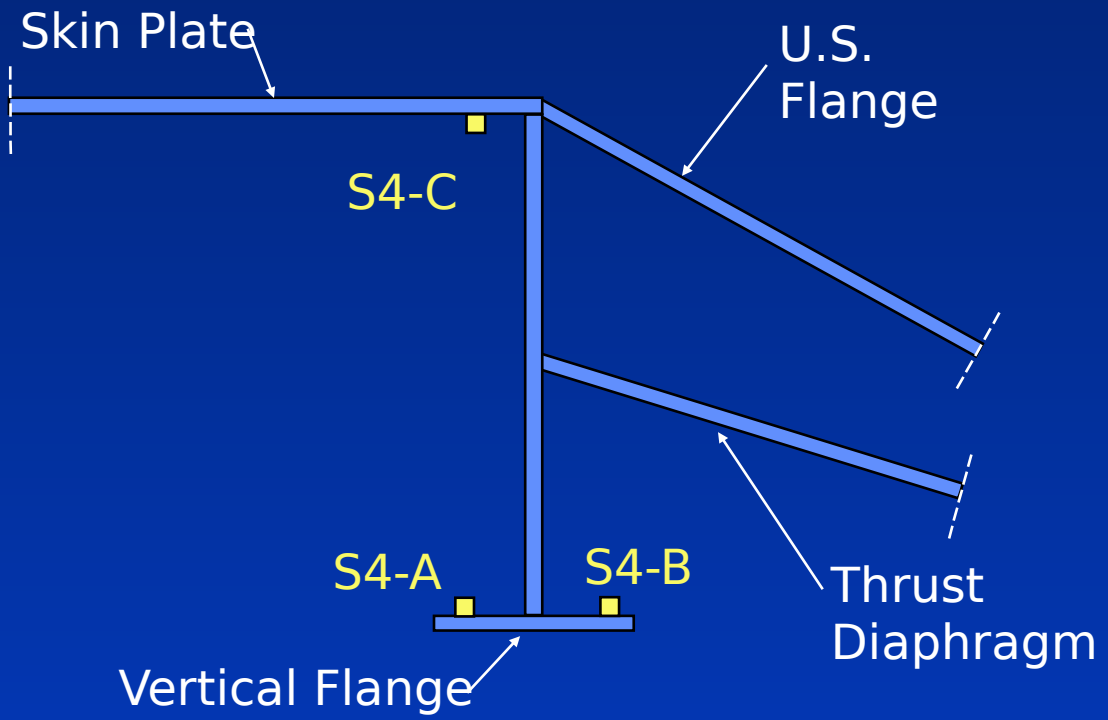


Miter End

Detail



Strain Gage Installation

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HiTech Products Strain Sensor

ERDC technician Tommy Carr welding down a strain gage

Cable Protection

Cable protection was done with flex tubing and a 1-1/2” conduit run from the top of the gate to the bottom

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Gate Position Measurement

Celesco String Potentiometer

Gate position was monitored using a string potentiometer attached to the hydraulic ram

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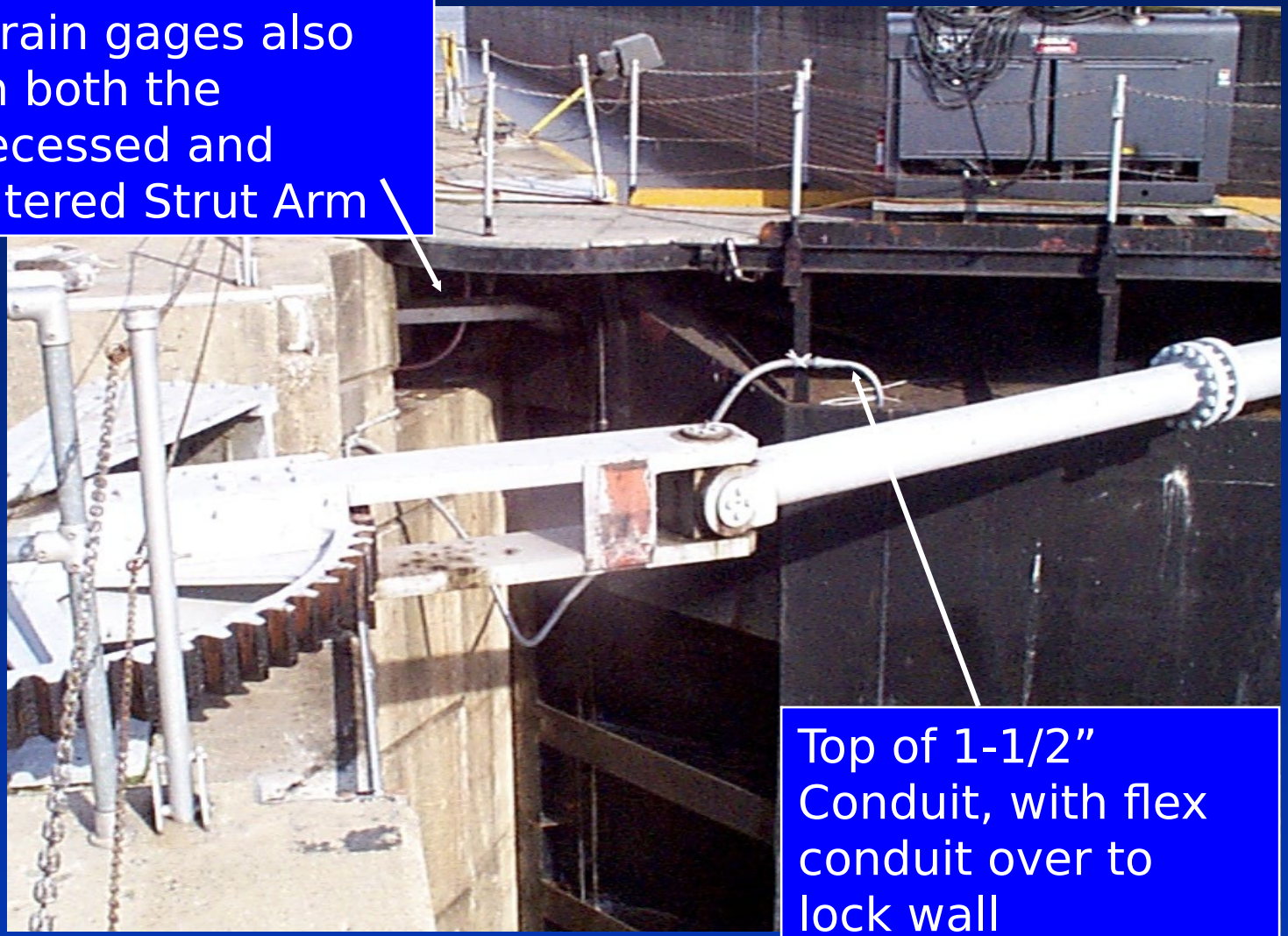
Gage Installation

Strain gages also on both the Recessed and Mitered Strut Arm



Top of 1-1/2” Conduit, with flex conduit over to lock wall

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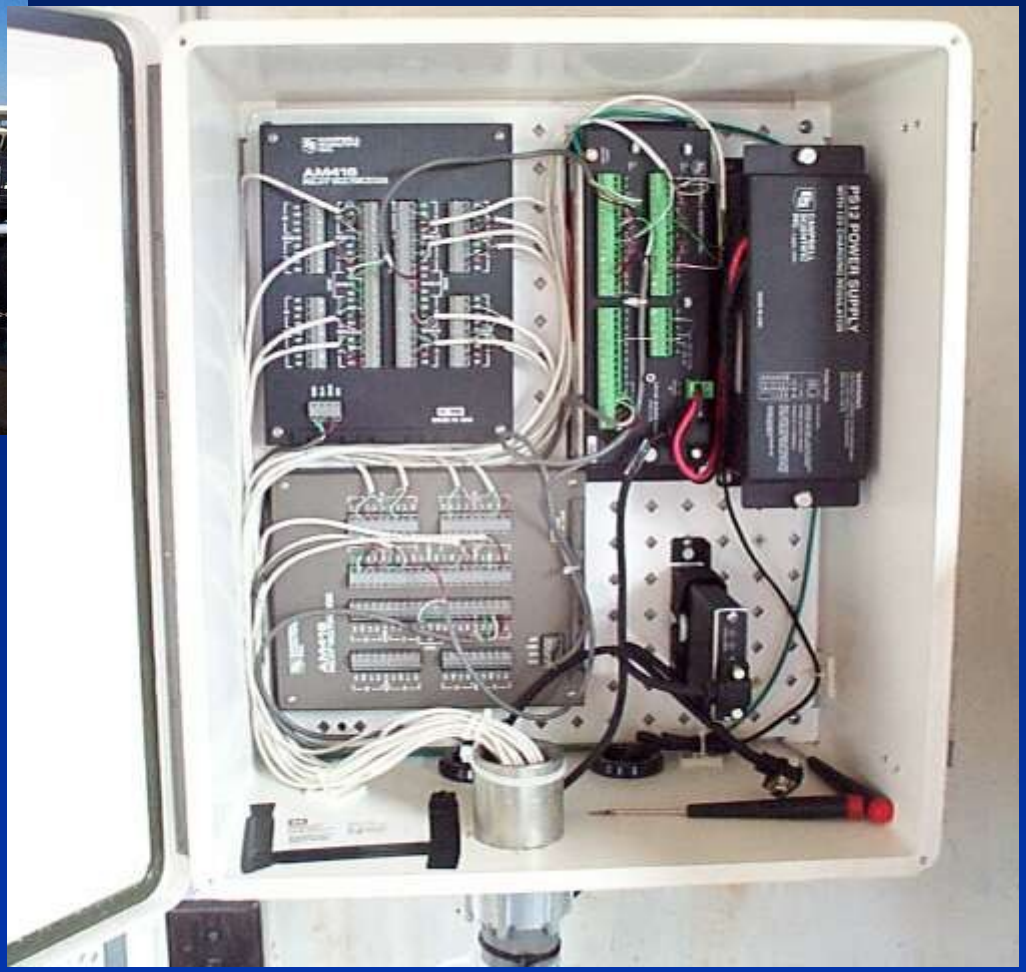
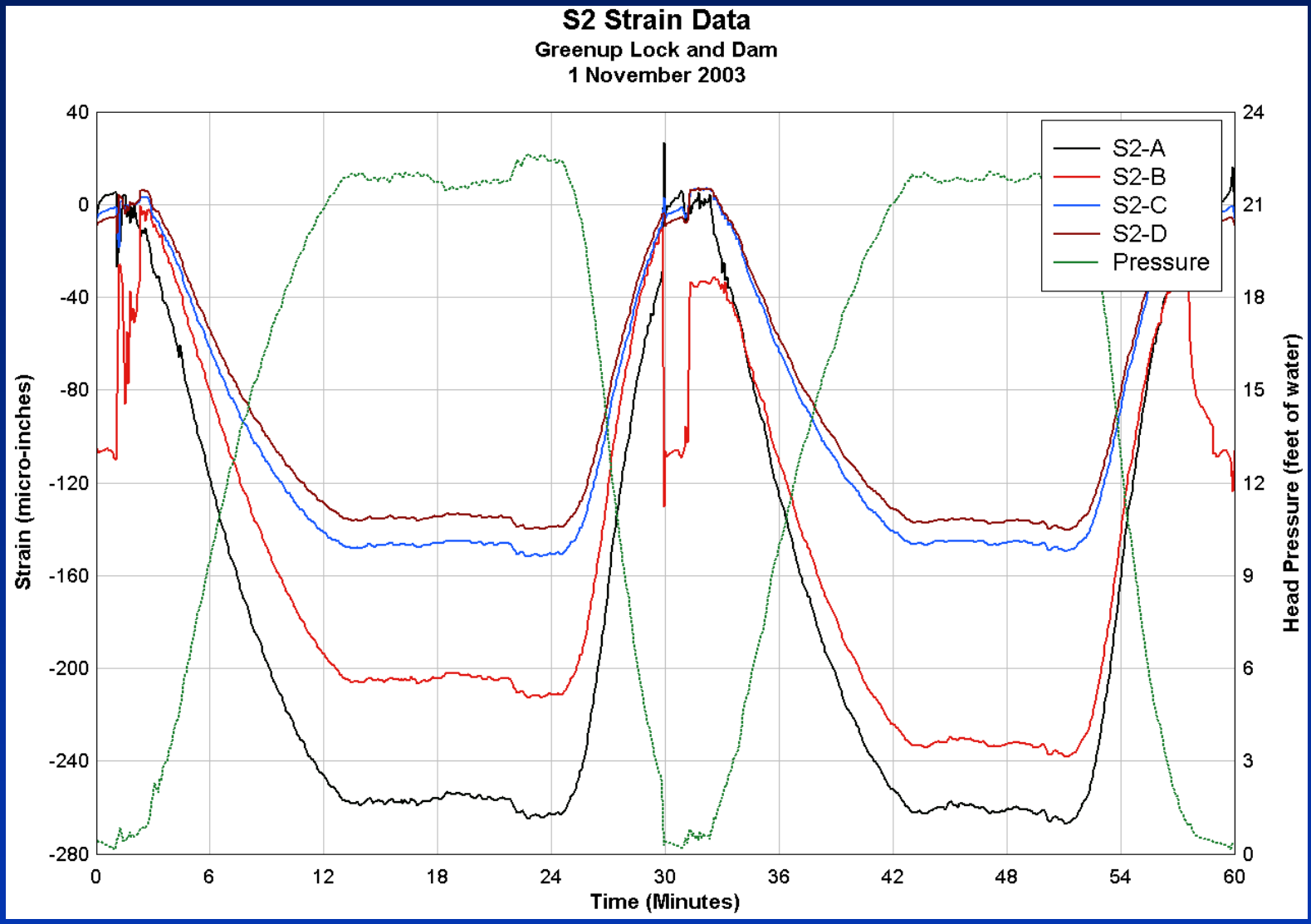
Data Logger



Campbell Scientific
CR10X Data logger
Installed in gate control
building

Strain Data – S2 Gages



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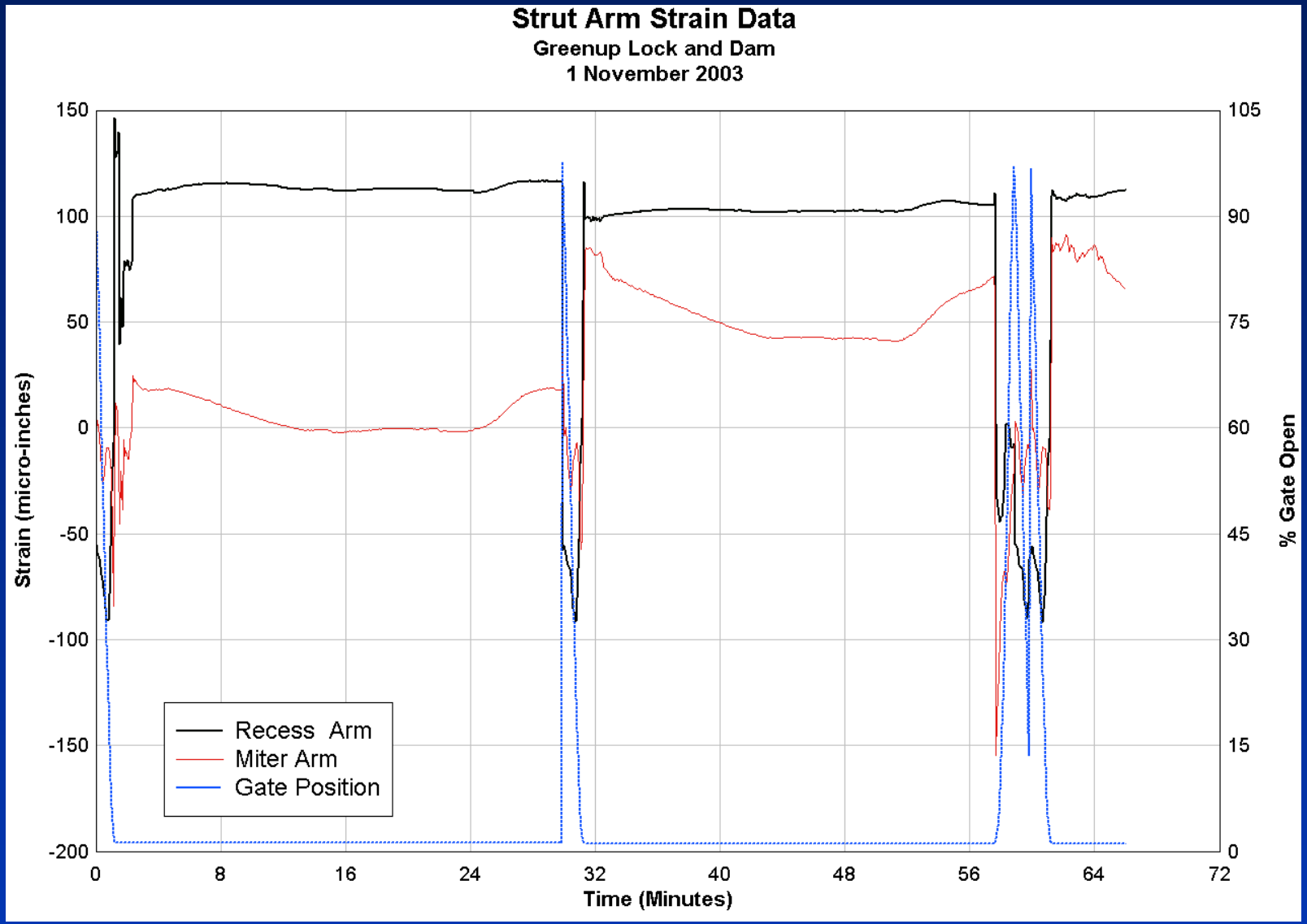
Strain Data – Strut Arms



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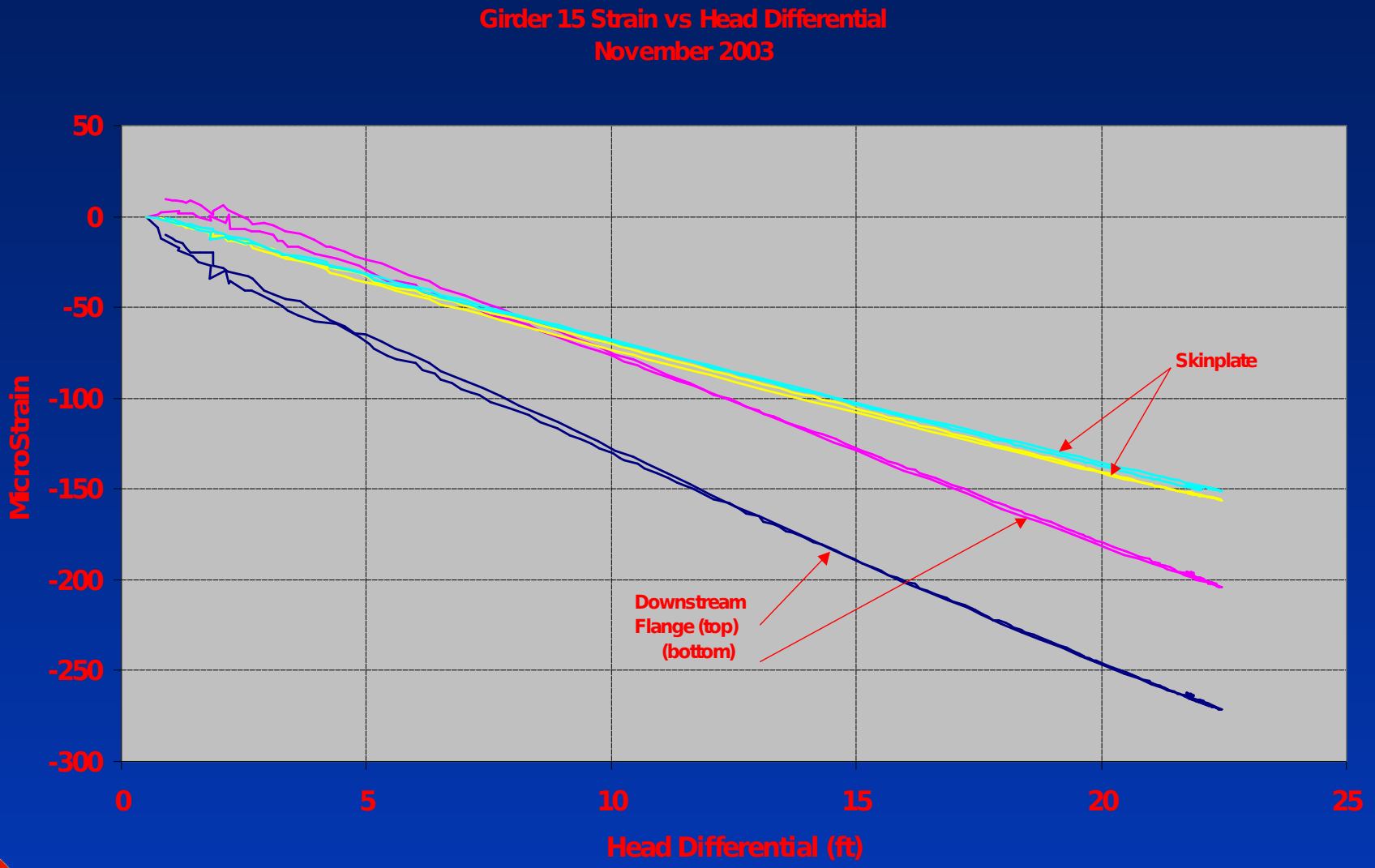

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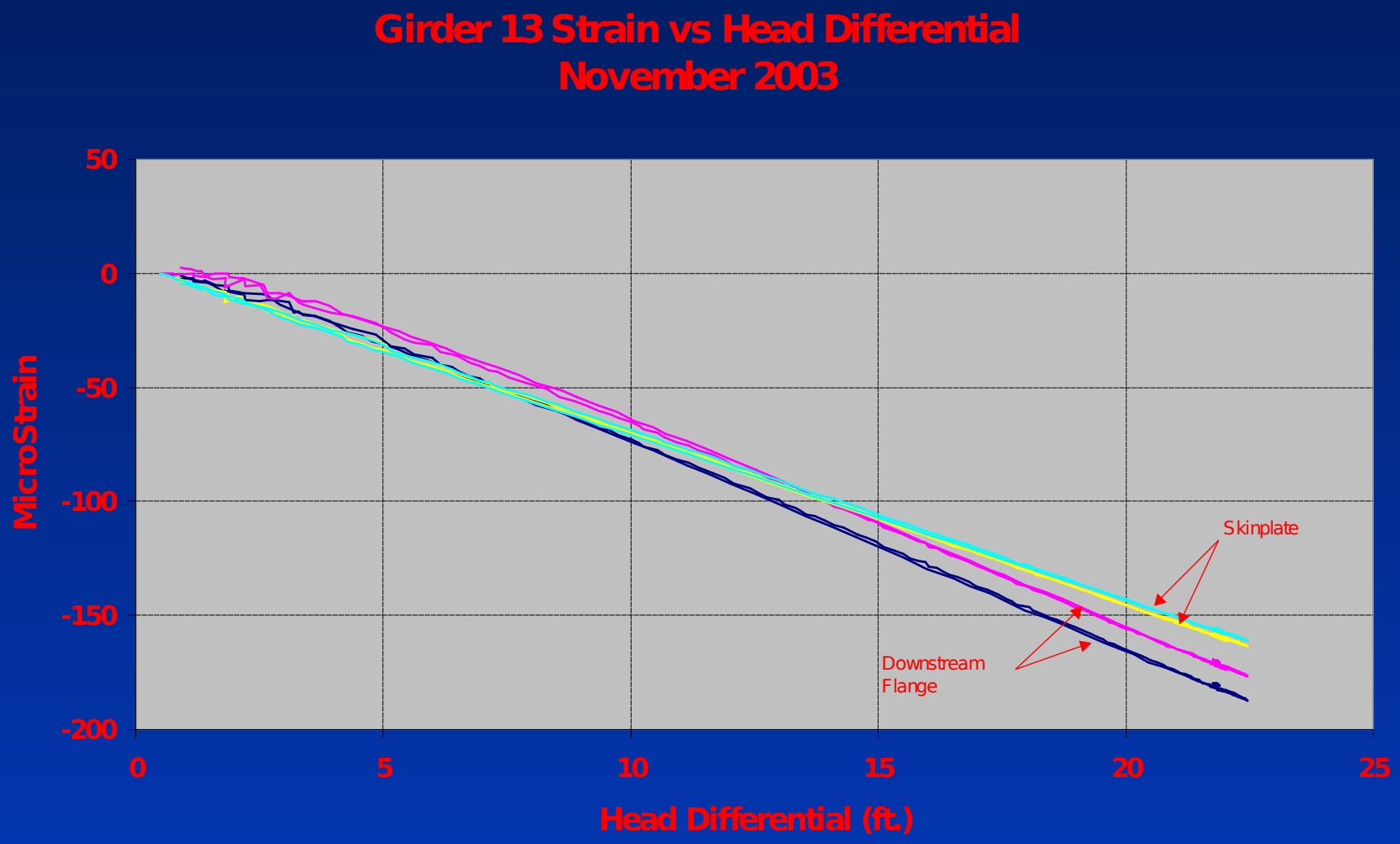

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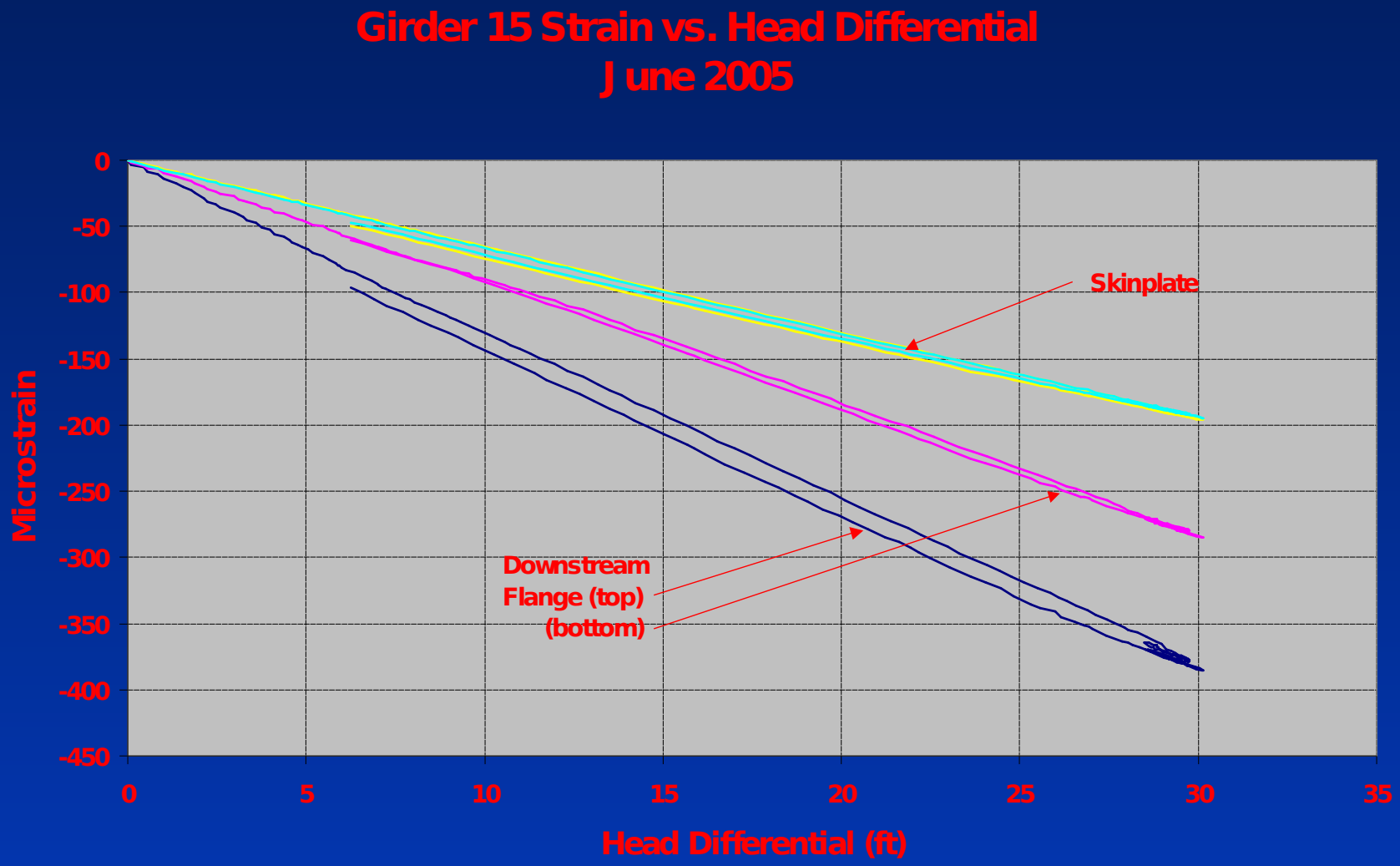

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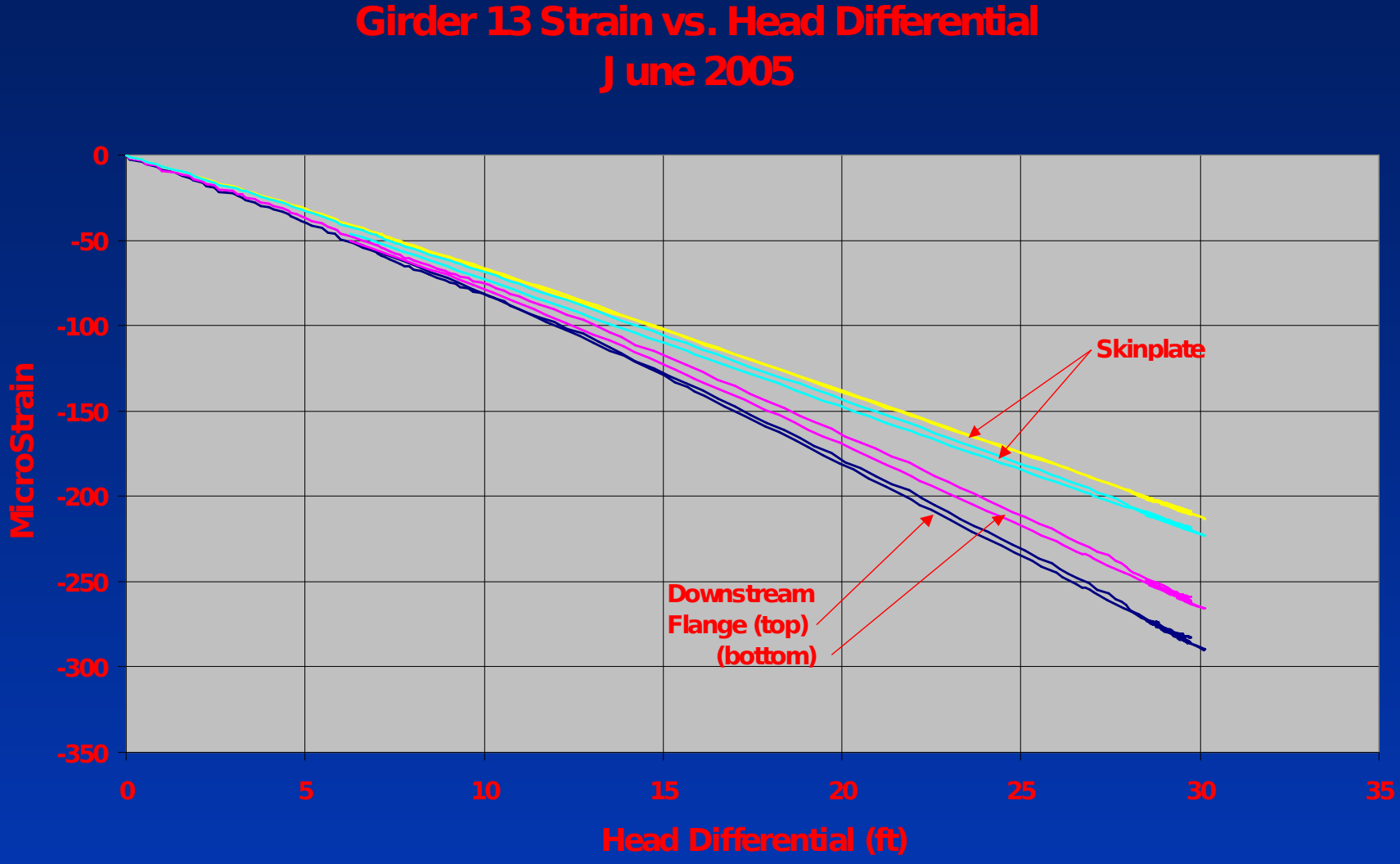

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Instrumentation – Lessons Learned

Conclusions

- Installing instrumentation around emergency gate repairs is difficult
- A durable and lasting strain monitoring system with automatic data logging and remote access was successfully implemented
- Instrumentation was installed with no impact to repair schedule and at minimal cost
- Preliminary results to date indicate behavior as expected

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Questions?